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Biology and Control of Sirococcus Shoot Blight on Red Pine

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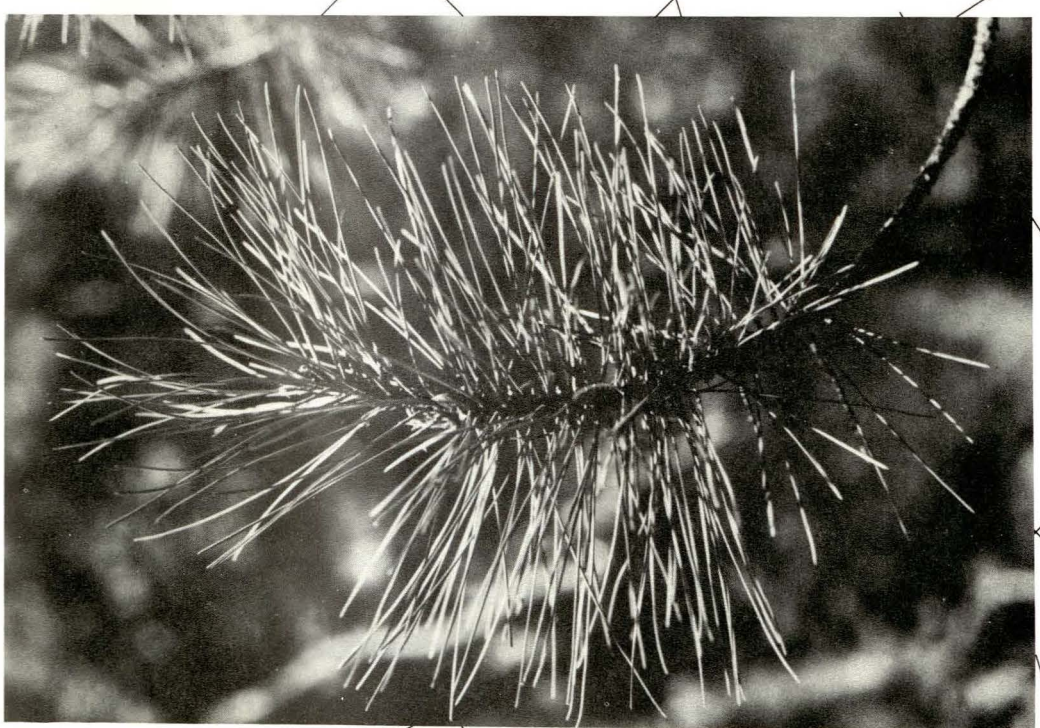

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Biology and Control of Sirococcus Shoot Blight on Red Pine

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Sirococcus shoot blight is caused by the fungus *Sirococcus conigenus* (DC.) P. Cannon & Minter (= *S. strobilinus* G. Preuss). This disease affects conifers in the northern United States and southern Canada (Nicholls and Robbins 1984). In the Lake States (Minnesota, Wisconsin, and Michigan), red pine (*Pinus resinosa* Ait.) growing in uneven-aged stands is most often seriously affected, resulting in growth loss, deformity, and death (Nicholls *et al.* 1981) (figs. 1 and 2, page 5). First detected in Wisconsin in 1959, the causal agent of the disease was determined to be *Sirococcus* in 1972 and reported on in 1973 (O'Brien 1973, Skilling and O'Brien 1973). This was the first report of *Sirococcus* on red pine. Sirococcus shoot blight became epidemic on many thousands of acres in the Lake States in the mid-1970's and periodic outbreaks continue in the United States and Canada on many species of conifers (Magasi 1975). Research on the life history of the fungus and control of the disease was begun by the North Central Forest Experiment Station in 1973. The purpose of this paper is to document our research results and to provide land managers with strategies to minimize damage to red pine caused by this disease.

MATERIALS AND METHODS

Impact and Host Range

In 1972, a study plot was established on the Northern Highland State Forest in Wisconsin. Each year from 1972 to 1976, 57 red pine growing under an infected red pine overstory and 43 red pine growing in the open were permanently marked and scored for Sirococcus shoot blight incidence and tree mortality.

In 1976, we examined 400 8-year-old red pine for shoot blight incidence on the Nicolet National Forest in Wisconsin to determine if uneven-aged management increased the incidence and impact of the disease. Half of the trees were growing in the open and the other half were growing under an infected red pine overstory.

To obtain information on the susceptibility of various conifer species to Sirococcus shoot blight in the Lake States, 2-year-old seedlings of 10 conifer species were planted in a field under infected red pine on the Northern Highland State Forest in Wisconsin in 1974. Seedlings were examined for the presence or absence of shoot blight symptoms in 1975 and 1976.

Life Cycle

The timing and pattern of spore dissemination and disease development of *S. conigenus* was studied in Wisconsin on the Northern Highland State Forest and Nicolet National Forest and in Minnesota on the Superior National Forest in 1973 and 1974. Six vaseline-coated microscope slides were used to trap spores at each of the three study sites (Ostry and Nicholls 1982). Four of the slides were placed directly under infected red pine, and the remaining two slides were placed at various distances from those trees within openings in the stands to determine the potential for long-range spore dispersal. In order to obtain more detailed information on long-distance spore dispersal, 11 spore traps were placed within an opening of a red pine plantation

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on the Nicolet National Forest. The spore traps were placed at distances ranging from 5 to 68 feet from infected red pine. A rain gauge was used to measure the weekly rainfall. Spore traps were changed weekly, and laboratory spore counts were made using a microscope.

Host phenology and symptom development were recorded weekly throughout the growing season. Red pine shoot samples were collected weekly for closer examination of symptom and fruit body development. Laboratory isolations were made on potato-dextrose agar to confirm the presence of *S. conigenus*. Potted healthy red pine seedlings were placed under infected red pine for 2-week intervals throughout the growing season to determine when infection took place. After exposure, the seedlings were placed in a greenhouse to observe symptom development.

Cultural Control

Two studies were established on the Nicolet National Forest and one each on the Northern Highland State Forest and the Superior National Forest to determine if sanitation would reduce disease incidence within red pine plantations. In the first study, shoot infections were removed from trees growing adjacent to, but not under, an infected red pine overstory. The second study examined the effectiveness of removing the infected overstory and/or the infected shoots of affected trees.

Removing infected shoots—In the spring of 1973 all infected shoots were clipped off 40 8-year-old red pine on the Nicolet National Forest. Another 40 trees served as controls and infected shoots were not removed. The number of new infected shoots on each tree was recorded in the fall. Infected shoots were again removed from the treatment trees in the spring of 1974 and 1975 and the incidence of new infections on all trees recorded each fall. A similar study was established on the Superior National Forest in a 10-year-old plantation of red pine.

Removing infected overstory—In May of 1975, on the Northern Highland State Forest and the Nicolet National Forest, the infected overstory trees were removed in an attempt to reduce inoculum in a portion of 10-year-old plantings of red pine. Four treatments were used: (1) removal of infected shoots from nearby open-grown trees, (2) removal of infected shoots from the released trees, (3) removal of infected shoots from trees remaining under infected overstory trees, and (4) control—no removal of overstory and infected shoots. Infected trees and shoots were either burned or removed from the stands to eliminate inoculum sources. Shoot blight incidence on the trees was recorded every fall from 1976 to 1979.

Chemical Control

To develop a control for shoot blight in nurseries, four fungicides previously shown to limit the growth of *S. conigenus* in laboratory tests were used in a study established in the spring of 1977 on the Northern Highland State Forest. The following chemicals were tested: chlorothalonil (Bravo 6F) (Tetrachloroisophthalonitrile), captafol (Difolatan 80W) (cis-N-(1,1,2,2-Tetrachloroethyl) thio)4-cyclohexene-1,2-dicarboximide, folpet (Phaltan 50W) (N-(Trichloromethyl) thio) phthalimide, and maneb (Manzate 200 80W) (Manganese ethylenebisdithiocarbamate). A total of 1,200 2-0 red pine seedlings were planted in six 200-tree beds for each fungicide tested. To determine the importance of shade in disease development, one-half of the beds were established in the shade of a healthy red pine overstory and the other half were planted in the open. Infected red pine shoots with fruit bodies of *S. conigenus* were placed on wire screens over the beds of trees to provide inoculum. Spore traps were placed within the beds and read weekly to confirm spore dissemination. From 1 to 3 applications of each fungicide were applied at the rate of 100 ml of a 0.3 percent active ingredient spray solution per bed of trees. This was sufficient to thoroughly cover the foliage of the seedlings with the solution. Fungicides were sprayed on May 24, June 15, and July 19, which were selected based on data obtained in our spore release and host development studies. Unsprayed beds of trees served as controls. Disease incidence data were collected in the fall.

RESULTS AND DISCUSSION

Impact and Host Range

The study plot established on the Northern Highland State Forest in 1972 showed that the Sirococcus shoot blight incidence was signifi-

cantly greater on the understory trees, red pine mortality in the understory trees increased 48 percent and none of the trees in the open died (table 1).

Observations made in 1976 on the Nicolet National Forest showed that only 5 of 200 red pine growing in the open were affected by shoot blight. In contrast, 140 of the 200 red pine growing under an infected overstory were infected by *Sirococcus*.

Results of the host range tests revealed that ponderosa pine (*P. ponderosa* Dougl. ex Laws.) and red pine were most severely affected. Jack pine (*P. banksiana*) was moderately susceptible. None of the other conifer species we tested became infected (table 2). Sirococcus shoot blight, however, has been reported on many other conifer species (Nicholls and Robbins 1984).

Table 1.—*Impact of Sirococcus shoot blight on red pine, Northern Highland State Forest, 1972-1976*

Year	Location	Trees killed	Infected shoots	Mortality
		Number	*---Percent--*	
1972	Opening[1]	0	21	0
	Understory[2]	10	85	19
1973	Opening	0	15	0
	Understory	16	90	30
1974	Opening	0	20	0
	Understory	23	90	45
1975	Opening	0	20	0
	Understory	30	95	59
1976	Opening	0	10	0
	Understory	34	95	67

[1]Sample size = 57 trees.
[2]Sample size = 43 trees.

Table 2.—*Susceptibility of conifers to* Sirococcus conigenus, *Northern Highland State Forest, WI, 1975 and 1976*[1]

Species	Trees sampled		Infected with *Sirococcus*	
	1975	1976	1975	1976
	Number		*Percent*	
Ponderosa pine (*P. ponderosa* Dougl. ex Laws.)	32	30	66	43
Red pine (*P. resinosa* Ait.)	34	28	44	46
Jack pine (*P. banksiana* Lamb.)	34	30	18	7
Scotch pine (*P. sylvestris* L.)	35	35	0	0
Austrian pine (*P. nigra* Arnold)	29	33	0	0
White pine (*P. strobus* L.)	36	36	0	0
White spruce (*P. glauca* (Moench) Voss)	32	32	0	0
Black spruce (*P. mariana* (Mill.) B.S.P.)	38	38	0	0
Norway spruce (*P. abies* (L.) Karst)	35	35	0	0
Balsam fir (*A. balsamea* (L.) Mill.)	40	0	0	—

[1]2-0 stock planted in 1974 under a red pine overstory infected by *S. conigenus*.

Life Cycle

Major spore release occurred in May and June both years at all locations (figs. 3 and 4, page 9). This coincides with red pine shoot emergence and needle elongation. Most spores were trapped on slides placed under infected trees with the number of spores greatly diminishing on slides placed at greater distances from infected trees (table 3). Spores were found only on traps exposed during rainfall, indicating that spores are released during wet weather and are disseminated mainly by rainsplash. Some spores may be carried longer distances by strong winds. Symptoms of infection were first visible in late June in the form of pitch droplets on affected shoots. Infection of shoots early in the season can kill them before they are fully elongated (fig. 5, page 6). Infections later in the season cause browning at the base of current-year needles, and eventually the entire current-year shoot dies (fig. 6, page 6). Cutting into infected shoots exposed the typical symptom of resin-soaked wood. The potted red pine seedlings exposed during the May-June period also became symptomatic and pure cultures of Sirococcus conigenus were isolated from them (fig. 7, page 6), providing further evidence that infection takes place at this time. Later, shoots died and needles drooped (fig. 8, page 7). The fungus overwintered on dead infected shoots (fig. 9, page 7). Mature fruit bodies and conidia were present on 1-year-old dead shoots (figs. 10 and 11, page 7 and 8).

Cultural Control

Removing infected shoots—The number of new shoots that became infected on trees that had all previously infected shoots removed was significantly less than the control trees on the Nicolet (table 4) as well as at the study site on the Superior. Most of the treated trees that had infected shoots were adjacent to infected overstory trees that provided the inoculum. Based on our spore dissemination study, long-range spore dispersal was limited, indicating that risk of infection decreases as distance from infected trees increases.

Removing infected overstory—Removing infected shoots on understory trees along with removing overstory red pine significantly reduced the incidence and severity of shoot blight compared to either removing infected shoots on understory trees only or the control trees growing under an overstory (table 5). Results on the Northern Highland State Forest also demonstrated that removing the overstory significantly reduced disease incidence. These results indicate that sanitation and even-aged management can minimize the incidence of Sirococcus shoot blight within plantations.

Table 3.—*Dispersal distance of* Sirococcus conigenus *conidia,*[1] *Nicolet National Forest, WI, May 7 to July 23, 1975*

Distance from nearest infected tree (feet)	Spores trapped	Total spores
	Number	*Percent*
0 - 9	323	40
10 - 19	407	50
20 - 29	50	6
30 - 39	8	1
40 - 49	5	1
50 - 59	9	1
60 - 69	8	1

[1]Vaseline-coated microscope slide spore traps were located at various distances from 30-year-old overstory red pine infected with *Sirococcus conigenus.*

Chemical Control

Applying fungicides significantly reduced shoot blight incidence (table 6). One spray in May was as effective as two or three sprays in June and July (figs. 12 and 13, page 8). All four chemicals gave some degree of control, however chlorothalonil and folpet gave the best control. At this time, chlorothalonil is registered for use

Table 4.—*The effect of removing infected red pine shoots on the incidence of new* Sirococcus conigenus *infections, Nicolet National Forest, WI, 1973-1975*

Treatment	Trees with newly infected shoots		
	1973	1974	1975
		Percent	
Infected shoots removed yearly	17[1]	14	28
Control	83[1]	86	72

[1]Sample size = 20 trees.

Figure 1.—*Sirococcus shoot blight of understory red pine saplings in Wisconsin.*

Figure 2.—*Red pine saplings growing under an infected red pine overstory illustrating a high hazard site. Note infected shoots on understory trees.*

Figure 5.—*Curling of current-year shoot infected by* Sirococcus conigenus.

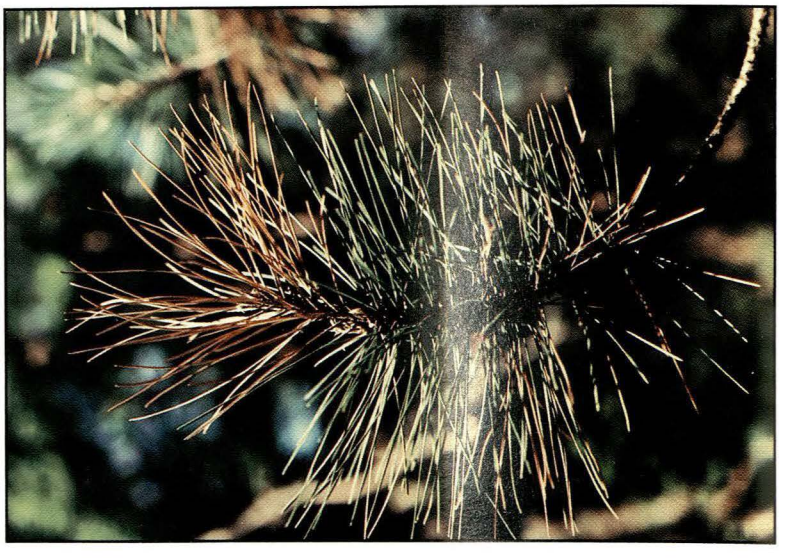

Figure 6.—*Browning of current-year needles of red pine infected by* Sirococcus conigenus.

Figure 7.—*Culture of* Sirococcus conigenus *obtained by placing sections of infected shoots on potato-dextrose agar.*

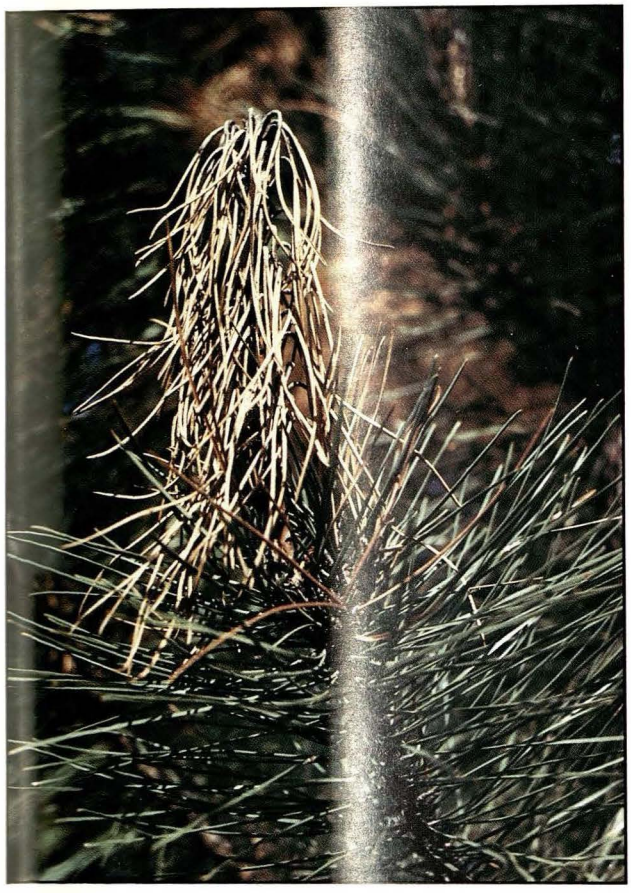

Figure 8.—*Drooping red pine needles of a current-year shoot infected by* Sirococcus conigenus.

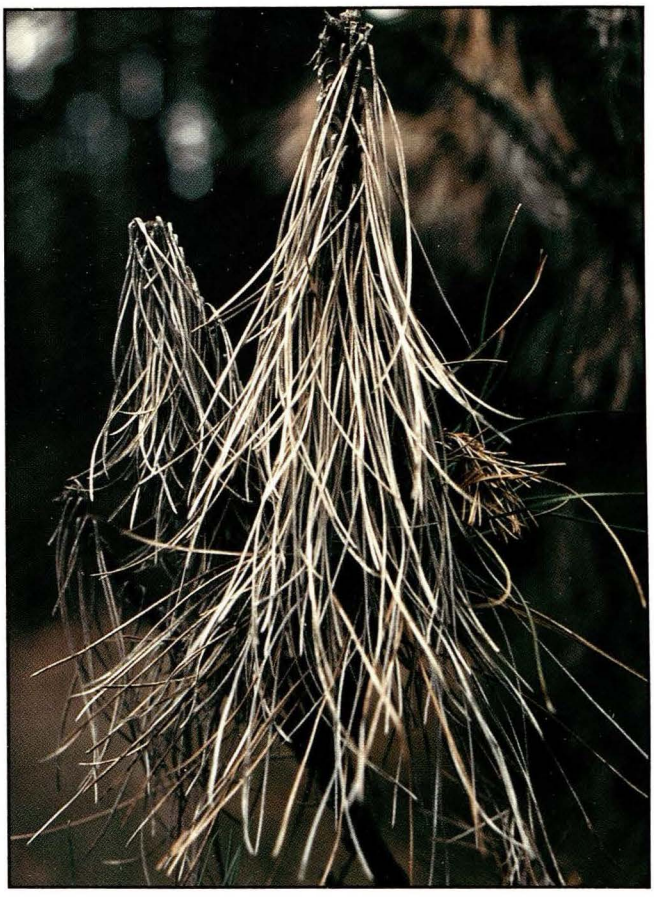

Figure 9.—*One-year-old dead red pine shoot killed by* Sirococcus conigenus *the previous year.*

Figure 10.—*Fruit bodies of* Sirococcus conigenus *at base of infected 1-year-old needle.*

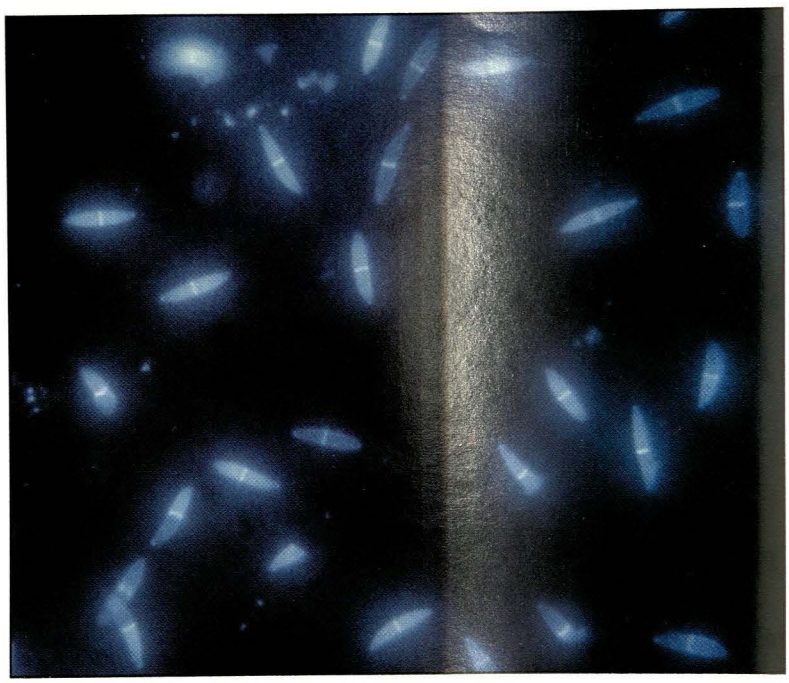

Figure 11.—*Two-celled* Sirococcus conigenus *conidia labeled with a fluorescent brightner and photographed under ultraviolet light (400X).*

Figure 12.—*An unsprayed bed of red pine seedlings illustrating the high mortality caused by shoot blight.*

Figure 13.—*Healthy red pine seedlings protected by a fungicide.*

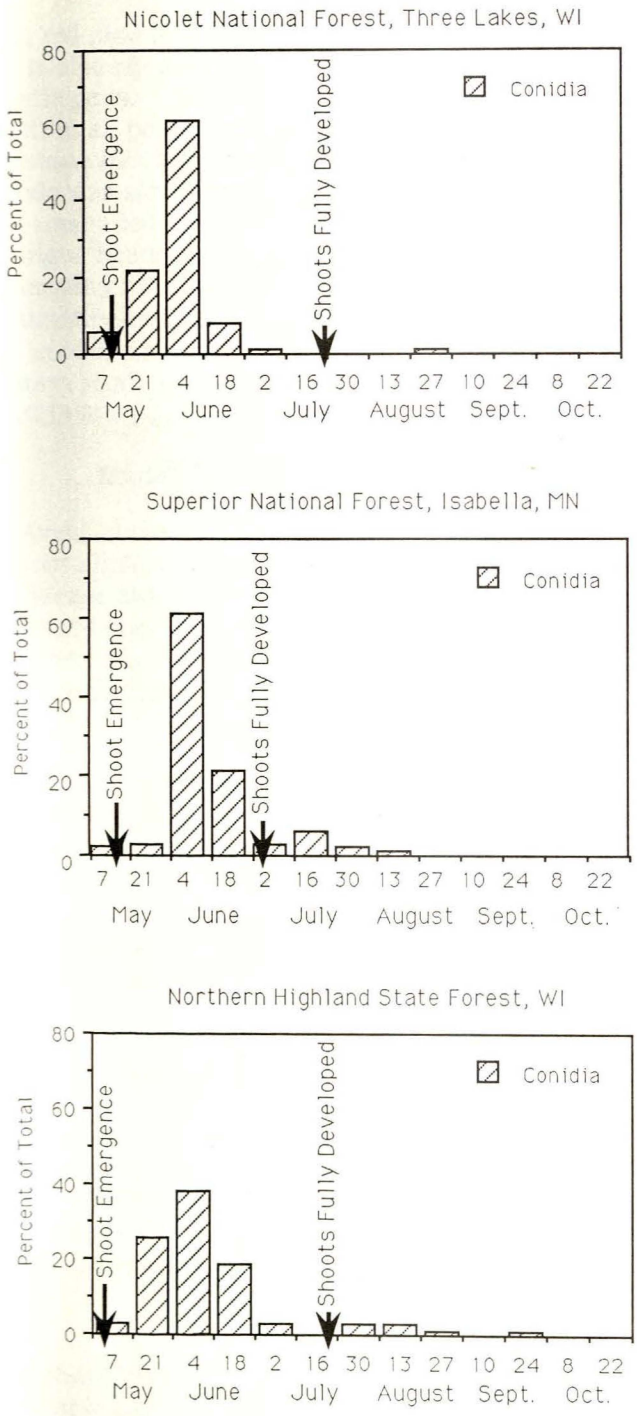

Figure 3.—Sirococcus conigenus *conidia dispersal and red pine shoot growth, 1973.*

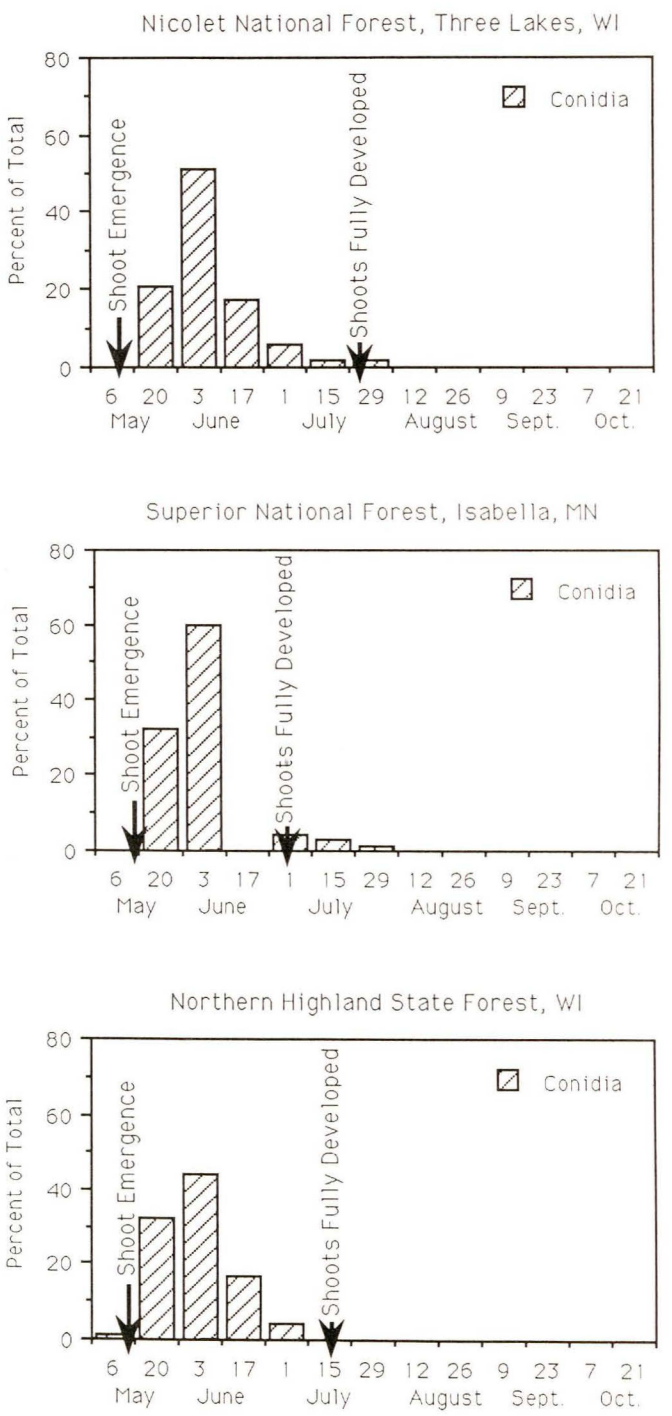

Figure 4.—Sirococcus conigenus *conidia dispersal and red pine shoot growth, 1974.*

Table 5.—*New* Sirococcus conigenus *infections on red pine within each of four treatments, Nicolet National Forest, WI, 1976-1979*

Treatment[1]	Trees sampled	Trees with new infections[2]			
		1976	1977	1978	1979
	Number	*- - - Percent - - -*			
Removal of infections on even-age, open-grown trees	63	0a	0a	25a	30a
Removal of infected overstory, and understory infections	101	0a	0a	20a	17a
Removal of understory infections, no removal of infected overstory	133	32b	19b	77b	91b
No removal of infected overstory or understory infections	57	49c	45c	95c	96c

[1]Treatments applied May 21, 1975.

[2]Values in the same column not followed by the same letter are significantly different (P = 0.05).

Table 6.—*Effectiveness of fungicides on control of* Sirococcus conigenus *on red pine seedlings, Northern Highland State Forest, WI, 1977*

Treatment[1]	Sprays[2]	Shaded beds		Nonshaded beds	
		Trees sampled	Trees infected	Trees sampled	Trees infected
	- - - Number - - -		*Percent*	*Number*	*Percent*
None	0	400	36	400	4
Chlorothalonil (Bravo 6F)	1	200	2	200	0
	2	200	0	200	0
	3	200	2	200	0
Folpet (Phaltan 50W)	1	200	1	200	2
	2	200	4	200	0
	3	200	0	200	0
Maneb (Manzate 200 80W)	1	200	6	200	8
	2	200	8	200	1
	3	200	7	200	0
Captafol (Difoltan 80W)	1	200	11	200	2
	2	200	14	200	7
	3	200	17	200	4

[1]Each bed of trees was treated with 100 ml of spray solution at a concentration of 0.3 percent active ingredient.

[2]The three spray dates were May 24, June 15, and July 19, 1977. Disease incidence was recorded on October 6, 1977.

on red pine to control *S. conigenus* in nurseries; it is also effective against several other conifer pathogens. Even though inoculum was present within all beds as indicated by the spore traps, disease incidence on seedlings in the shaded beds was significantly greater than on seedlings in unshaded beds. This indicates that the fungus needs shade and the associated higher humidity for infection. The importance of high humidity and low light intensity for infection by *S. conigenus* was also demonstrated in an inoculation study using black spruce (*Picea mariana* (Mill.) B.S.P.) (Wall and Magasi 1976).

Management Recommendations

* Avoid uneven-aged stands where Sirococcus shoot blight is a problem. Do not plant under or adjacent to infected red pine. Because spores are disseminated from infected trees by rainsplash, provide a buffer zone at least twice the height of adjacent trees between planted and existing trees.

* Remove infected shoots from plantation trees when feasible and remove any scattered, infected large trees because they can serve as an inoculum source.

* Avoid planting high hazard sites such as shady, humid areas where the disease is favored.

* Plant resistant species adapted to the sites where Sirococcus shoot blight is a threat.

* Control *Sirococcus* in nurseries by properly timed applications of chlorothalonil at the label rate. Avoid using susceptible trees in nursery windbreaks because they could provide inoculum that can infect seedlings.

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Pesticide Precautionary Statement

This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife—if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

Use of trade names in this paper does not constitute endorsement by the USDA Forest Service.

Ostry, M.E.; Nicholls, T.H.; Skilling, D.D.
1990. **Biology and control of Sirococcus shoot blight on red pine**. Res. Pap. NC-295. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 11 p.

Describes the symptoms, host range, impact, biology, and control of Sirococcus shoot blight caused by the fungus *Sirococcus conigenus* in the Lake States.

KEY WORDS: *Sirococcus conigenus*, *Sirococcus strobilinus*, *Pinus resinosa*, plantation, silvicultural control, chemical control.

Our job at the North Central Forest Experiment Station is discovering and creating new knowledge and technology in the field of natural resources and conveying this information to the people who can use it. As a new generation of forests emerges in our region, managers are confronted with two unique challenges: (1) Dealing with the great diversity in composition, quality, and ownership of the forests, and (2) Reconciling the conflicting demands of the people who use them. Helping the forest manager meet these challenges while protecting the environment is what research at North Central is all about.